High Pressure Spaik Gap in an Inert Gas.

For some years I have employed a high-pressure spark-gap, such as that described by me in the *Phil. Mag.* for August, 1902, in connection with a Tesla inductive system, and I have experienced considerable trouble arising from the erosion of the spark balls and their supports. They soon become coated with an oxide of the metal employed, and the sparking becomes unsteady. As a cure for this evil, which contributed much to the formation of a bad type of spark, the employment of some inert gas suggested itself to me; and of such gases Mr. C. C. F. Monckton proposed the use of nitrogen, and this gas I now use instead of air. I find that after the continuous use of nitrogen in the spark-gap the balls are but little affected, while the spark through a gas pressure of 50 lb. per square inch is compact and constant in shape, and the yield of the induction apparatus is greatly enhanced. The spark-gap globe is filled to the required pressure from the gas cylinder through a reducing valve, and when it is shut off the pressure is maintained for ten or twelve days nearly up to the initial one.

The nitrogen, which was supplied by the British Oxygen Co., compressed in a steel cylinder, turned out to be very nearly pure; it is separated from liquefied air, and is certainly more pure than hydrogen as supplied in cylinders, and gives better results. The spheres are made of thick white glass, and are tested to about four times the load they are worked under. The spark ball is advanced by means of a fine screw forty-eight threads to the inch, cut on ¼-inch rod, working in a boss which forms a part of the gun-metal cap with which the glass globe is closed. If the screw is carefully fitted by Whitworth screwing apparatus, no gland or stuffing-box is required. The screw is slightly lubricated with a mixture of equal parts of pure india-rubber and vaseline. The length of the spark is measured by means of a divided head attached to the screw.

It might be supposed that a long spark in air at normal pressure would have the same effect as a spark shortened by gas pressure; but experimental evidence shows that the thick, steady, well-formed spark made under pressure gives far the most trustworthy results. Sparks made in air at normal pressure often do not strike from the nearest surfaces, but strike along an arched path, this effect reducing the discharge and rendering it variable in its intensity; but when the high-presseure nitrogen spark-gap is employed, the discharge from the Tesla apparatus is steady and unvarying during periods of time such as forty or sixty minutes.

F. J. Jervis-Smith.

The Small Motion at the Nodes of a Vibrating String.

It is generally recognised that the nodes of a string which is maintained permanently in oscillation in two or more loops cannot be points of absolute rest, as the energy requisite for the maintenance of the vibrations is transmitted through these points. I have not, however, seen anywhere a discussion or experimental demonstration of some peculiar properties of this small motion. A brief note may therefore be of interest.

In the first place, the small motion at the node is in a phase which is different from that of the rest of the string. The exact difference of phase is shown by a dynamical investigation to be a quarter of an oscillation. The motion is of very small amplitude, and it might therefore be thought a difficult matter to verify this experimentally. I have, however, devised some convenient arrangements with which this can be effected. I shall here mention only one method: this was to compound the oscillation at every point on the string with another perpendicular to it of half the frequency, and to observe the compound oscillation at the nodes and elsewhere.

Such a compound oscillation can easily be maintained permanently by having the string attached to the prong of an electrically maintained tuning-fork, so that it lies in a plane perpendicular to the prongs, but in a direction inclined to the line of their vibration. When the load on the string is slightly greater than that necessary for the most vigorous maintenance, points on the string describe parabolic arcs with concavities in opposite directions in alternate loops, the whole forming a beautiful and interesting type of stationary vibration. This is not, however, the stage convenient for observing the small motion at the nodes. When the tension of the string is relaxed, so as to make its vibration stronger, points on the string, *i.e.* except the node, describe 8 curves. The curve described by the node is neither a straight line nor an 8 curve, but is a very flat parabola. From this, the phase-relation between the small motion at the nodes and the large motion elsewhere is obvious.

If the node has a small motion, then, strictly speaking, there is no node at all. There should, however, be points at which the positions of the string in opposite phases might be supposed to intersect. One might suppose that these points, or "fictitious nodes," should execute a very small, almost microscopic, movement. As a matter of fact, these "fictitious nodes" oscillate parallel to the string through a range equal to the whole length of a loop. This somewhat striking effect may be observed without difficulty by illuminating the string with periodic illumination of twice the frequency of the oscillation.

Post-Box 59 Rangoon. C. V. Raman.

An Instance of Prolonged Pupation.

The following facts in connection with a specimen of the privet hawk-moth may possibly be of interest to some of your readers.

The caterpillar, which was reared from the egg at Tunbridge Wells, pupated between August 7 and 9, 1906, and the pupa was sent out to me by post. The moth did not emerge until October 16, 1908, having been more than two years in the pupal state. Being the only specimen I have, I cannot say whether it shows any variations; but it is not stunted, measuring just over 4 inches across the expanded wings.

Geo. H. Wyld.

Sydney, N.S.W.

A SCIENTIFIC MISSION IN ETHIOPIA.[1]

Abyssinia—and even in a more general way the whole Empire of Ethiopia—though it was the first portion of tropical Africa to come within what one might term the scientific cognisance of the civilised world, the world of Mediterranean Europe and Western Asia, remains, nevertheless, to this day the least understood and one of the most imperfectly explored parts of Africa. In all probability, more is known about the fauna, the flora, the human races, and languages of even the most recently revealed recesses of the Congo Basin, of the Central Sudan, the Liberian hinterland, and the south-western part of the Niger Basin (to mention some of the least-known parts of tropical Africa) than is recorded of the dominions of the Emperor Menelik.

This ignorance of Ethiopia (from the point of view of modern science) is, of course, proportionately estimated in relation to the extraordinarily important position all this region occupies in the study of Africa, in the solution of African enigmas. It is an area of about 200,000 square miles, containing exceptionally high mountains, the tops of which, but for the increasing aridity of North-East Africa, should be even more covered with glaciers than is the case with Ruwenzori, under the Equator, for the Ruwenzori range only exceeds in altitude by a few hundred feet the estimates of the highest points of northern and south-western Abyssinia. In Abyssinia alone, of all parts of tropical or Trans-Saharan Africa, may distinct evidences be found of the existence (on the high mountains and even in the plains) of a Eurasian fauna and flora—wild swine of the genus Sus, wild goats, wild dogs (*Canis simiensis*), and a few other beasts

[1] "Mission en Éthiopie (1901–3)." By Jean Duchesne-Fournet and others. Tome i., pp. xviii+440; Tome ii., pp. xv+388, and atlas. (Paris: Masson et Cie., 1909.)

and a number of birds, trees, and plants, which in their affinities belong more truly to the Palæarctic and subtropical regions of Europe and Asia than to true Africa. There are also indigenous non-Negro races, like the Gala, which, by skull formation, by their use of the plough (absolutely unknown elsewhere in Negro Africa), by their languages, and many other points, are Asiatic rather than African.

Yet there are indications that Abyssinia, like Somaliland, Egypt, Mauretania, has been inhabited by man from a most remote period. Abyssinia may have been the first great focus of *Homo sapiens* on the African continent, to the south of the Sahara Desert; the region from which radiated Pygmies, Bushmen, Nilotic Negroes, Forest Negroes, and Bantu; Hamite, Egyptian, and the widespread negroid types typified by the modern Fula, Hima, Nyam-nyam, and Tibbu. Here took refuge an ancient offshoot of the Jewish people; here first of all with the armies of Ptolemy, was carried Greek civilisation into tropical Africa; hither came Persians after they had conquered southern Arabia; even more anciently than Jew or Persian a branch of the Semitic peoples was implanted in Abyssinia, which has left behind to this day at least two distinct language-groups of the Semitic family—Amharic and Harrari—in addition to the much later Arabic.

Here we are in one of the few portions of tropical Africa known to the Romans and to the civilised kingdoms of India before the time of Christ. (*Habshi*—derived from *Habesh,* an old Semitic name for Abyssinia—is even at the present day the common word for *negro* throughout Hindustan, and is also equivalent to "magician," because in the ancient lore of India, Abyssinians were identified with all the unholiest forms of magic. They are the "black magicians" of the "Arabian Nights'" stories. When the present writer first imported Sikh soldiers into Central Africa to fight the Arab slave traders, brave as they were in the presence of Arabs, they were at first frightened of the friendly negroes. "He is a Habshi, and will turn me into a rabbit," said one stalwart Sikh soldier to me when I asked him to travel alone through the bush with a negro guide.)

The Portuguese soldiers and missionaries first revealed some marvels of Abyssinia and Ethiopia to the modern European world of the later Renaissance. The Portuguese also, by splendid feats of arms, saved Christian Abyssinia from being conquered and effaced by a great army of Arabised Somalis under Muhammad Granye. Then came an interval of Abyssinian distrust of the greedy white man, and the attempts of Louis XIV. to supplant the Portuguese and frenchify Abyssinia in the seventeenth and eighteenth centuries led finally to great disasters, though it increased the acquaintance of the European world with these profoundly interesting countries. After that came the awakening of British interest through the travels of Bruce and Salt. The last named (Henry Salt) added considerably to our knowledge of the peculiar fauna of these countries.

During the first half of the nineteenth century, French interest in Abyssinia had a notable revival, and to the brothers D'Abbadie (of French-Irish origin) we owe much of our meagre knowledge of the Hamitic and negroid dialects of western Abyssinia and south-west Ethiopia. After this came British big-game hunters, consuls, and, finally, an army of British and Indian soldiers. Mr. W. T. Blandford, amongst other notabilities in zoology and geography, accompanied this expedition, and again revealed further remarkable features in the mammalian fauna of this peculiar part of Africa.

We have learnt a little more since from British and Italian missionaries and explorers (notably, as to fauna, from Major Powell Cotton), but more still from French expeditions, important among which have been those of the late Baron Carlos d'Erlanger and Baron Maurice de Rothschild.

One of the most remarkable French expeditions (not forgetting the work of Borelli some sixteen years ago) lately undertaken for the examination of Abyssinia and Ethiopia, is that which is the motive and the source of the present notice.

In a rather too intimate and emotional preface to this work, addressed to the father of Jean Duchesne-Fournet, we are told that this young and brilliant French explorer died in 1904, after his return from Abyssinia. In the course of his journeys he had reached the Wallaga country during the rainy season, and had suffered to a terrible extent from fevers, the sequelæ of which caused his death after his return to France. He was, in fact, a martyr to science, for the Wallaga country is a very little known part of East-Central Africa, lying to the south of the Blue Nile and of the Didessa River, and at no great distance from the frontier of the Egyptian Sudan.

The special object of Duchesne-Fournet's exploration of Wallaga was its reputation, not only as a possible source of future wealth in gold, but as a region from which gold was obtained in the distant past for the ancient Egyptians. Apparently a concession had been granted in that region to a French syndicate, and an active exploration was being carried on by a French engineer, Monsieur Comboul (who afterwards died). The Wallaga country has a mean elevation (averaging the French and Italian calculations) of about 6000 feet. It seems to have been visited by Jean Duchesne-Fournet alone (with an Algerian escort), or, at least, without any one of the French men of science on his staff, consequently, from the point of view of science, his incursion into this south-westernmost portion of the Emperor Menelik's dominions had little results of importance. He describes this country as "ravissant surtout avec sa belle verdure." It has a certain amount of woodland, rare elsewhere in the Abyssinian Empire. The rainfall is extremely heavy, and the country to a great extent lies within the basin of the River Didessa, an important southern affluent of the Blue Nile. It is covered with a luxuriant vegetation, and, where there is any agriculture (the land is inhabited sparsely by Galas and Walamo negroids), wheat, barley, maize, sorghum, beans, peas, potatoes, coffee, limes, bananas, and cotton are cultivated. The engineer Comboul seems to have found deposits of lignite, the importance of which was appreciated by the Emperor Menelik. But although in beauty this region was a paradise, and in products one of the richest parts in Africa, the climate seems to have been singularly unhealthy—constant fevers, not to be explained easily under the mosquito theory of infection, and terrible rheumatisms made its exploration during the rainy season almost a torture. Some of the great mountains (the summits of which would seem to reach here and there to 10,000 feet) contained immense caves, the exploration of which might yield important results in palæontology and palæanthropology.

The premature death of the leader of this expedition (the other members of which were Lieutenant Collat, Sergeant-Major Fontenaud, Louis Lahure—who afterwards greatly distinguished himself in explorations between the Benue and Lake Chad—H. Arsandaux, Dr. Goffin, and Dr. Moreau) to some extent spoilt the realisation of the full scientific results; as it is, the

material collected and presented in the two volumes and the atlas of this book, give us, first of all, a most important *aperçu géologique* of the Danakil country, French Somaliland, and southern Abyssinia as far as Addis-Abeba, and a petrographical study of the same regions, with analyses of the rocks and minerals collected, and many photographs to show the types of landscape. These photographs are most conscientious, but the country presented to our eyes between Addis-Abeba and the Gulf of Aden is certainly one of the least alluring of all Africa. The Sahara Desert is much more attractive from the painter's point of view.

Some beetles were collected and are described. There is a most important article (taking up a considerable proportion of the second volume) on the anthropology and ethnography of southern Abyssinia, by Dr. R. Verneau, of the Paris Museum of Ethnography. This is accompanied by admirable photographs of skulls, of clothing and adornments, of musical instruments, pottery, jewellery, and horse harness; but the photographs taken by the expedition of living human types are, with one or two exceptions, not good or trustworthy, since they have been too much touched up in order to make them presentable pictures, or else they are very minute. The author of this section (Verneau) would seem to have arrived at the following general conclusions:—That in the portions of Abyssinia and northern Ethiopia in which the Duchesne-Fournet expedition collected skulls and took careful measurements of the living body, there were, besides the pure-blooded Negro, three distinct human types:—(1) The *Amhara* or *Abyssinian* (with which might also be grouped the *Gala*; (2) the *nigritised Abyssinian* (simply the result of ancient and modern intermixture between the Hamite—Abyssinian, Gala—and the Negro); and (3) a most interesting form, the *Berber* (this is a short title for the descriptive term given by Dr. Verneau, who calls it, "Type Abyssin clair, à cheveux lisses ou ondulés," and elsewhere, "Berbère"). This "third ethnic element" he describes as "very different from those which I have already set apart." It is one which has made its influence felt in Abyssinia, but, like the Negro element, it has crossed with the Hamite or Ethiopian (type No. 1), and as the result of this mixture its characters have become sensibly attenuated. "Nevertheless, one may affirm that this type No. 3 is of a fair complexion, slightly *cuivré*, and is further notable because it has evidently lightened the complexion of the skin in 13·5 per cent. (approximately) of the actual population." "Type No. 3," he goes on to say, "has blue eyes, or must have had blue eyes originally; for one could scarcely derive the blue, grey, or green iris (which is that we have noted in the proportion of 11·7 per hundred amongst modern Abyssinians) from the Ethiopian or the Negro. It is also type No. 3 which has certainly introduced the smooth or very slightly undulating hair, which has been found in 13·2 per cent. of the individuals under examination. On the other hand, this light-skinned race has not introduced tall stature amongst the people, but rather lessened the stature of the Abyssinians as compared with that of the Hamite and negroid races farther south."

In this race, Dr. Verneau apparently sees a marked resemblance to the Kabail of Abyssinia. One of the skulls depicted seems to display affinities with the Cro-magnon race of Western Europe.

There is a most comprehensive bibliography of Ethiopia in this work under review, a work which whets one's appetite for a complete examination of Abyssinia.

H. H. JOHNSTON.

THE SYSTEMATIC MOTIONS OF THE STARS.[1]

A SYSTEMATIC character in the proper motions of stars was discovered by Herschel, and accounted for by the motion of the solar system in space. Herschel's conclusions were for a time disputed by Bessel, but were confirmed by Argelander, and have since been generally accepted. In the last quarter of a century many determinations of the direction of the solar motion have been made, but the results have not shown that accordance which might have been anticipated. Particularly noticeable are the different results obtained from the proper motions determined by Auwers of the stars observed by Bradley in 1750, and re-observed about 1860, according to the method employed. Applied to these stars, the mathematical methods of attacking the problem developed by Airy and Argelander place the solar apex, or point to which the sun is moving, in declination $+35°$ or thereabouts, while Bessel's method places it at $-5°$. In 1895, Dr. Kobold directed attention to these discrepancies, which seem to point to an error in the fundamental hypothesis underlying these methods of determining the direction of the solar motion. These methods are based on the assumption that the "peculiar" motions of the stars are haphazard, and have no preference for any particular direction or directions in space.

As an outcome of prolonged study of the subject, Prof. Kapteyn announced, in 1905, at the meeting of the British Association in South Africa, that this hypothesis was untenable. He used the well-determined proper motions of 2400 stars extending from the pole to 30° south of the equator given in Auwers-Bradley. Dividing this area of the sky into twenty-eight regions, he determined the directions of the apparent proper motions of the stars in each region, and found that they showed a preference for *two* special directions and not for one only. When these favoured directions for the twenty-eight areas were plotted on a sphere, they were seen to converge to two points. Convergence to a point on the sphere indicates that the apparent linear motions of the stars are parallel, just as the radiant point of a meteor stream indicates the direction in which the meteors are all apparently travelling. Relatively to the sun, therefore, the stars are moving in two streams, inclined at a considerable angle to one another; these motions are apparent only, and, when the solar motion is subtracted, are resolvable into two streams moving in diametrically opposite directions, relatively to the centre of gravity of the stars. Kapteyn showed that the stars were equally distributed among the two streams, and that their relative motion was in a line in the plane of the Milky Way, directed towards the star ξ Orionis (R.A. 91°, decl. $+13°$) and the opposite direction. The apparent motions of the stars are thus resolvable into a combination of (1) a haphazard motion, (2) the reversed solar motion relative to the centre of gravity of the stars, and (3) the stream movement in the direction of ξ Orionis and the opposite direction. It was pointed out by Kapteyn that the determinations of the solar motion made by Airy's method, the one most generally adopted by astronomers on account of

[1] (1) J. C. Kapteyn, Reports of the British Association for the Advancement of Science, 1905, p. 257.
(2) A. S. Eddington, Monthly Notices of the Royal Astronomical Society, 1906, vol. lxvii., p. 34, and vol. lxviii., pp. 104 and 588.
(3) K. Schwarzschild, Nachrichten von der Königlichen Gesellschaft der Wissenschaften zu Göttingen, 1907, p. 614, and February, 1908.
(4) S. Beljawsky, Astronomische Nachrichten, Band clxxix, p. 293.
(5) F. W. Dyson, Proceedings of the Royal Society of Edinburgh, 1908, vol. xxviii., part i., p. 231; 1909, vol. xxix., part iv., p. 376.